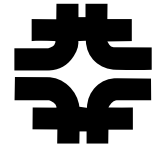


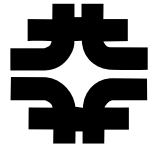
BOOSTER 30 HZ HARMONIC

Dan Wolff

Fermilab

March 29, 2005

Outline

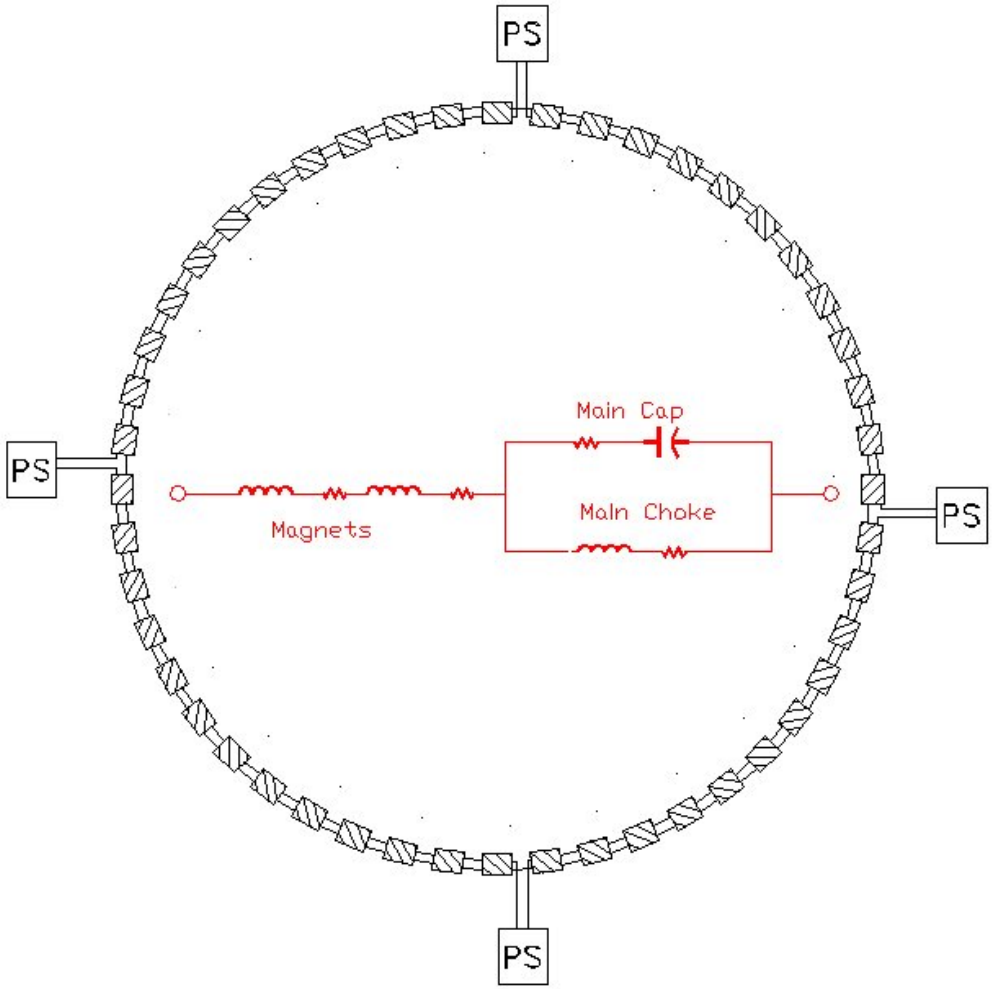


- Purpose
- Present Booster
- Changes needed for 30 Hz operation
- Risks
- Status of Testing at E4R
  - Test facility near MI 60 Service Building
- Tasks Needed to be Completed
- Time Line

Booster 30 Hz - Purpose

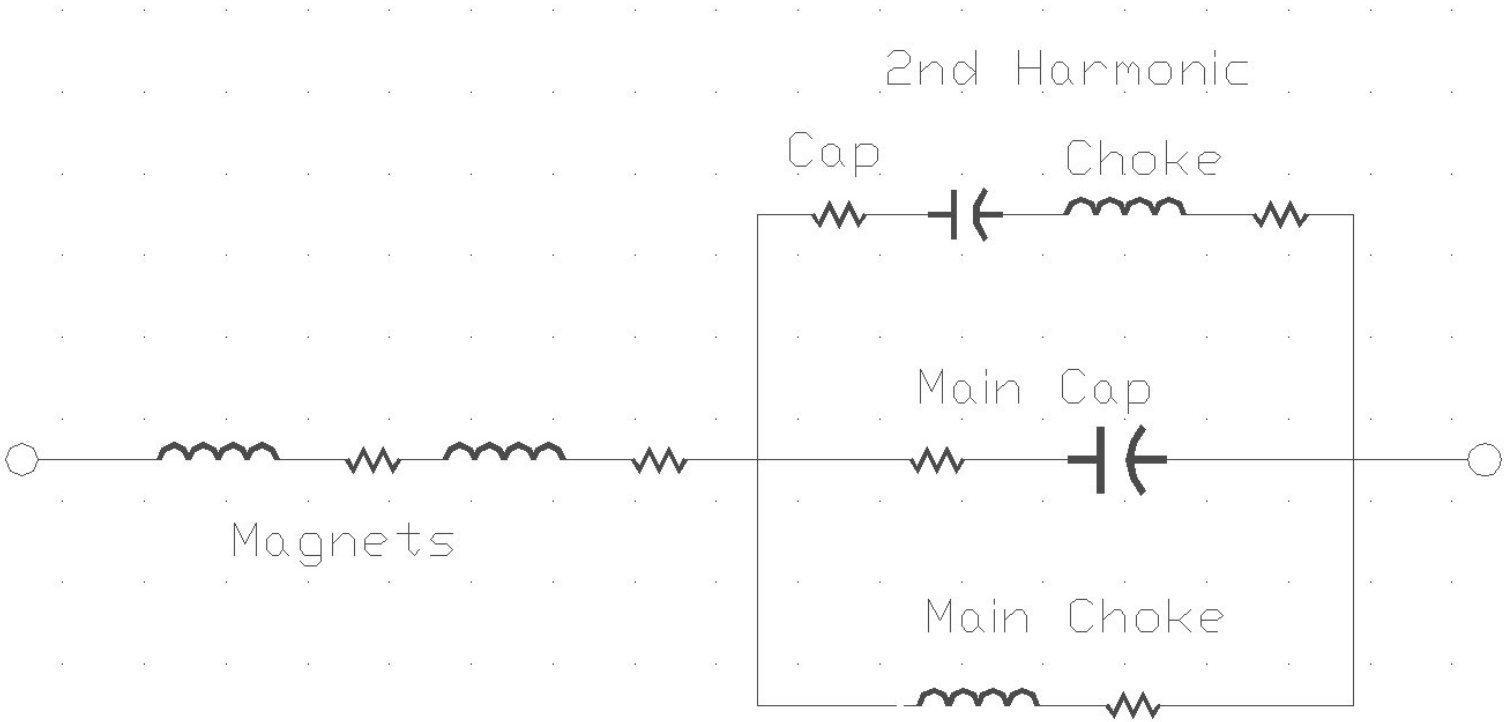
- The purpose is to decrease the maximum dE/dt in booster magnets and thus increase the RF capability (bucket area)
- Goal is to keep present magnets, chokes, and capacitors.
- Add additional components as necessary

Booster Block Diagram

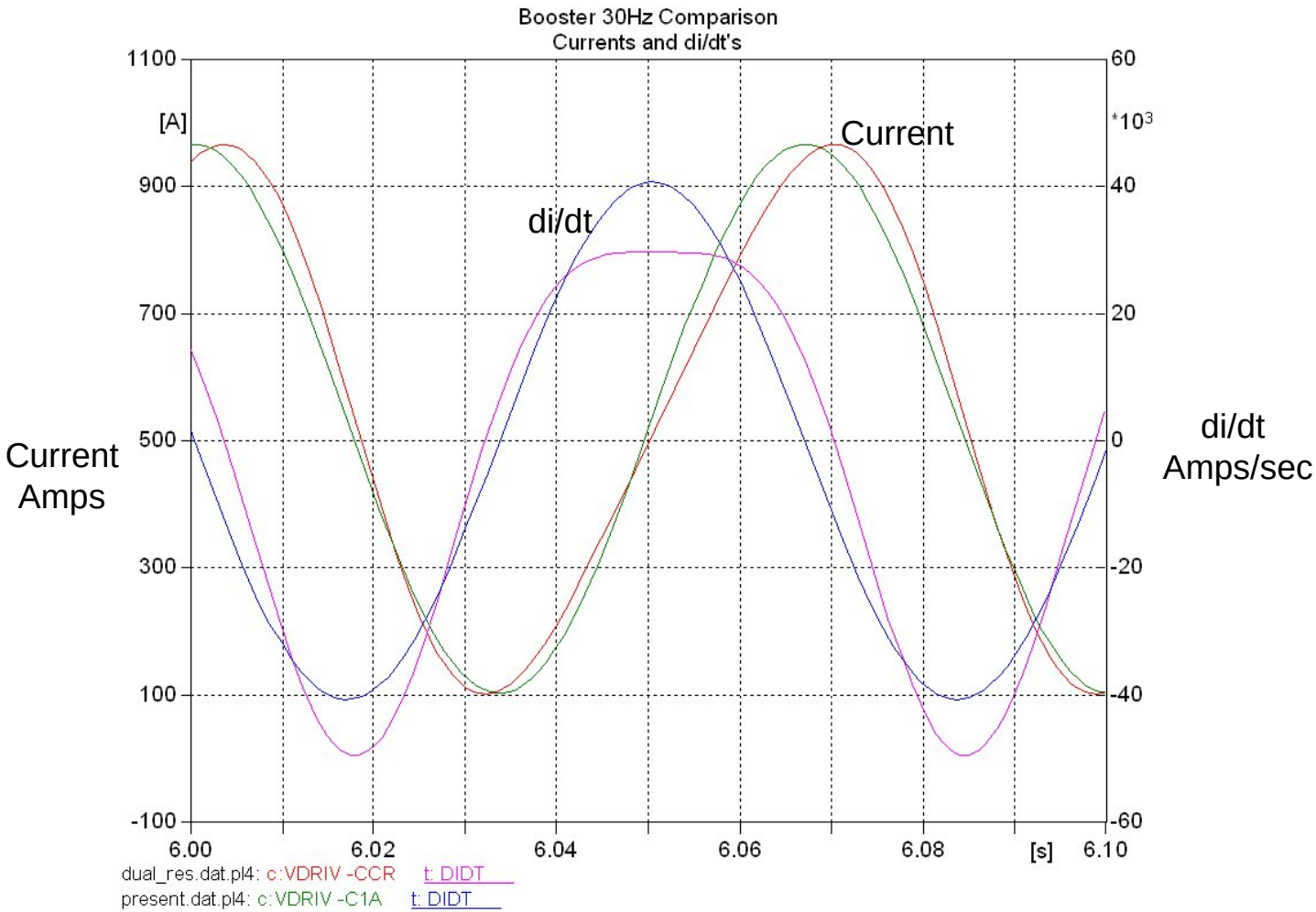


Booster Girder (at E4R)

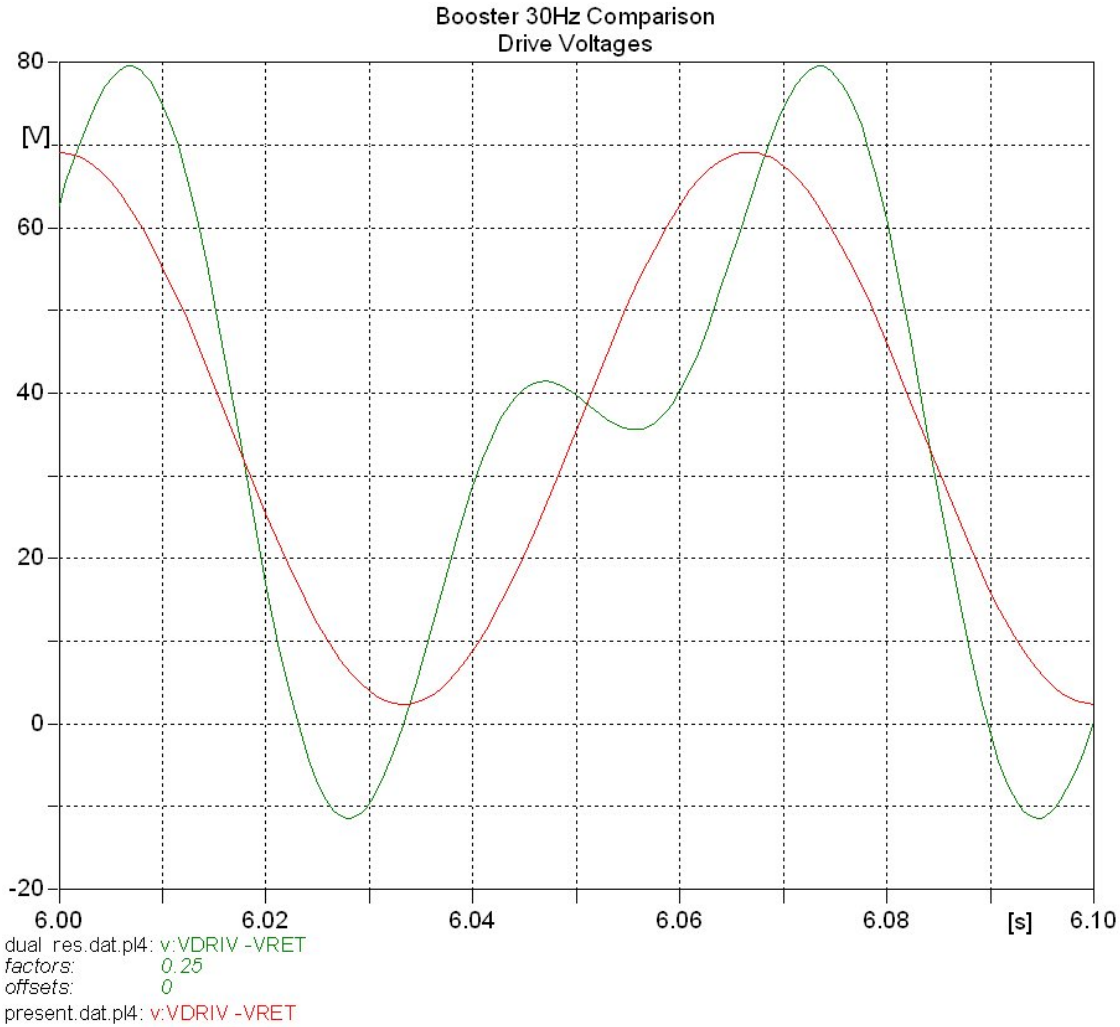
Booster 30 Hz Cell Diagram



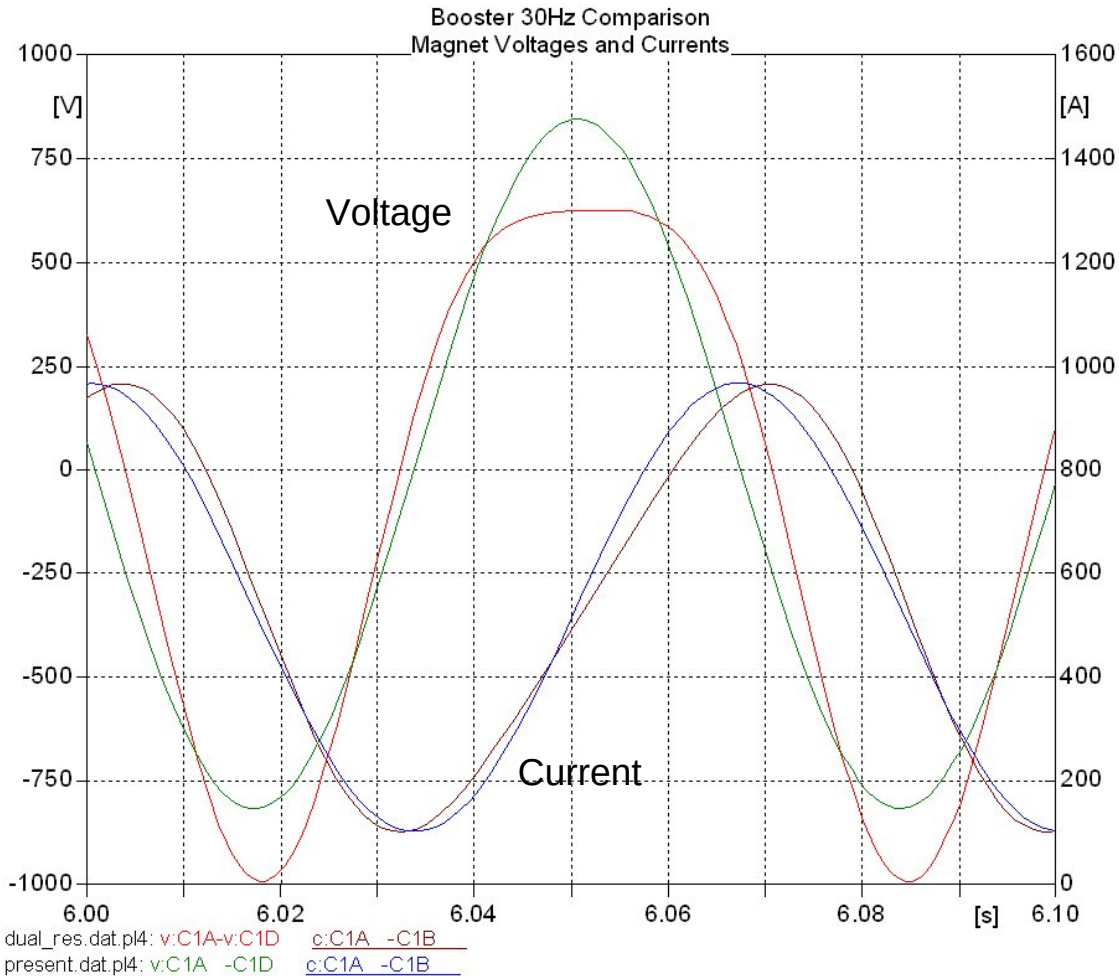
Current and di/dt Waveforms



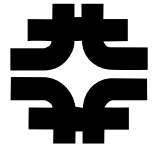
Drive Voltage Waveforms



Magnet Voltage and Current Waveforms



Power Supply Changes Needed



- Power supplies need to invert
- All 4 existing power supplies will be needed for normal operation.
- New second harmonic cap bank is needed.
- New second harmonic choke is needed.
- New regulation system needs to be developed.

Risks

- Increased Voltage Stress

  The dual resonance mode will increase the voltage stress on the magnets, inductors, and capacitors by as much as 30%.
- According to the manufacturer, the existing capacitors may be nearing the end of their life.

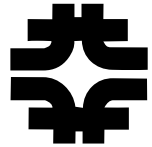
  20 year life under spec operating conditions

  Procured in 1985

  Lifetime sensitive to operating voltage, current and temp.
- Unknown affect on AC line.

  An additional 30 Hz component will be added to the AC line affecting the entire footprint area (WH, Linac, MR conv., etc)
- Full compliment of power supplies are required for operation.

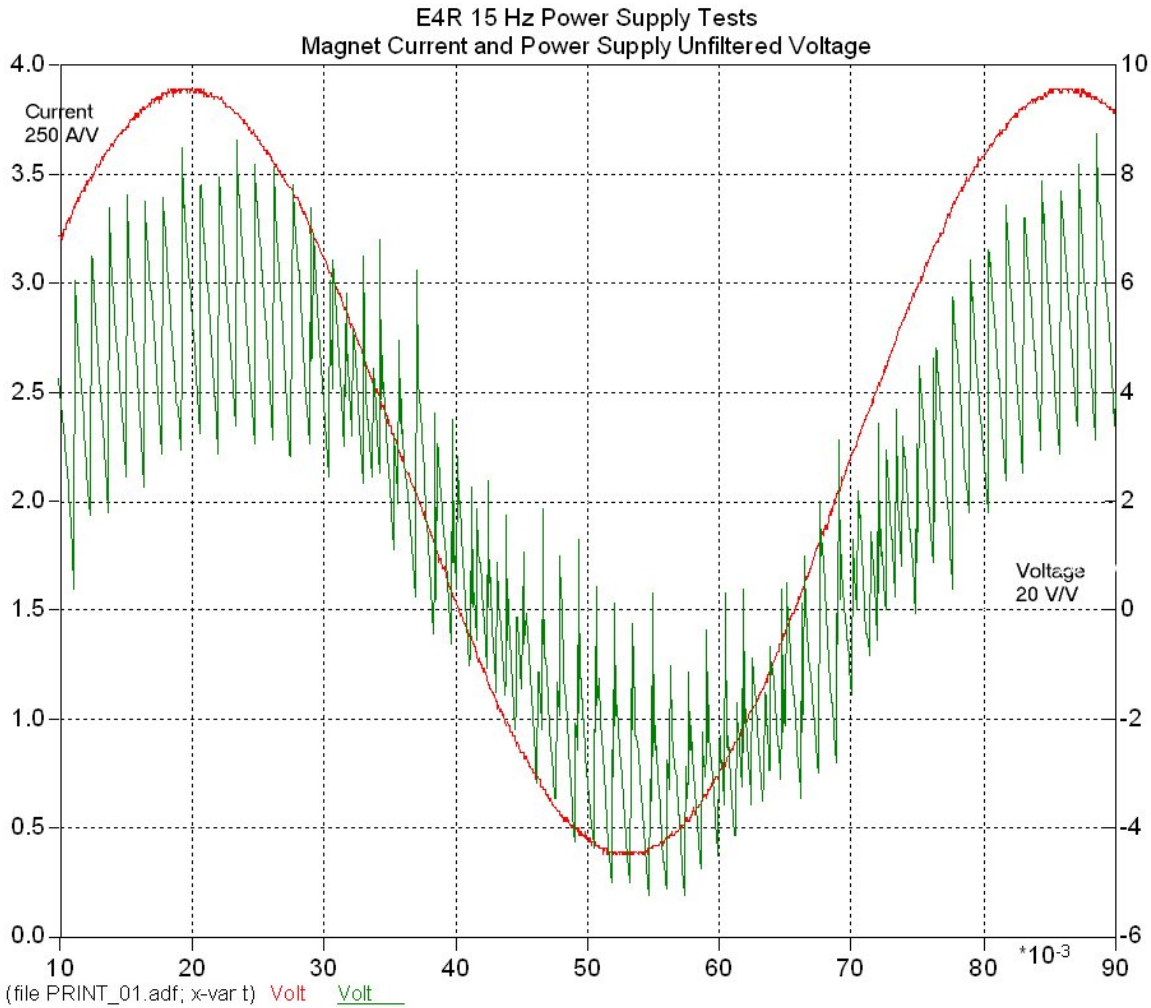
Status of Testing at E4R



- Operating at 15 Hz for over a year
  - Spare Booster girder driven by a 500kW power supply
- Received 30 Hz choke a few months ago
  - Choke did not quite meet saturation specification, might be OK but needs in-circuit testing
  - Building a choke in house to help understand the effect of loses and saturation on circuit performance.
- Installed proto-type current regulator
  - Operation Successful for 15 Hz
  - Still investigating effect of A/D resolution and uP cycle time on regulation.
  - Waiting for 2^{nd} harmonic

E4R Power Supply

E4R 15 Hz Testing - waveforms

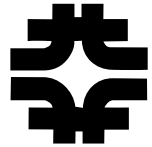


30 Hz Choke

Tasks

- Complete testing at E4R
  - Finalize the design/specification for 2nd Harmonic Choke
  - Verify basic approach of regulation scheme
  - Develop a methodology for tuning
- Evaluate feasibility of physical changes needed to booster girder
  - Use E4R as a prototype
  - Determine cost/manpower/time needed
- Perform computer simulations to study AC line affects

Tasks (cont.)

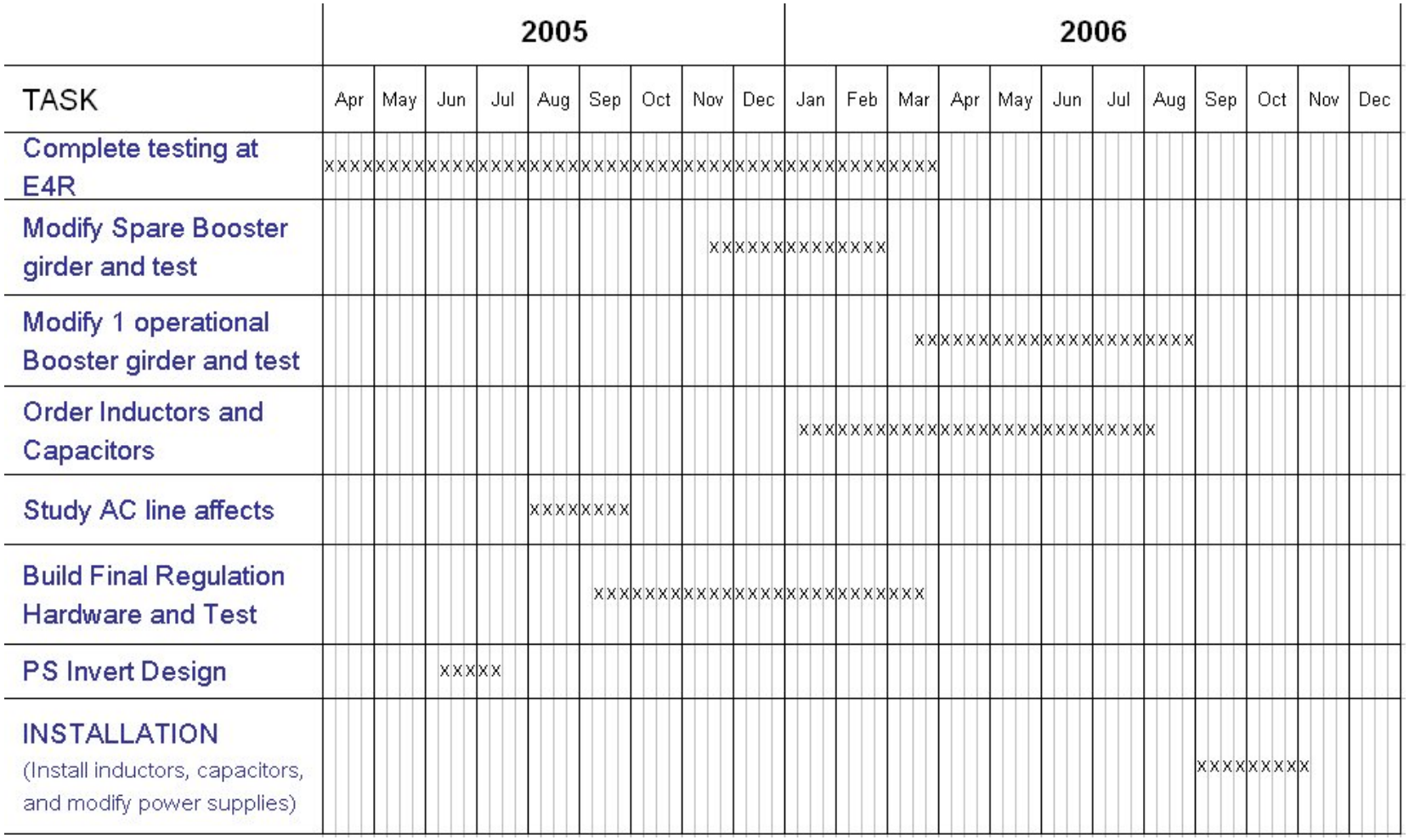


- Modify 1 operational Booster girder

  Will a cell tuned to 15/30 Hz work with existing cells?

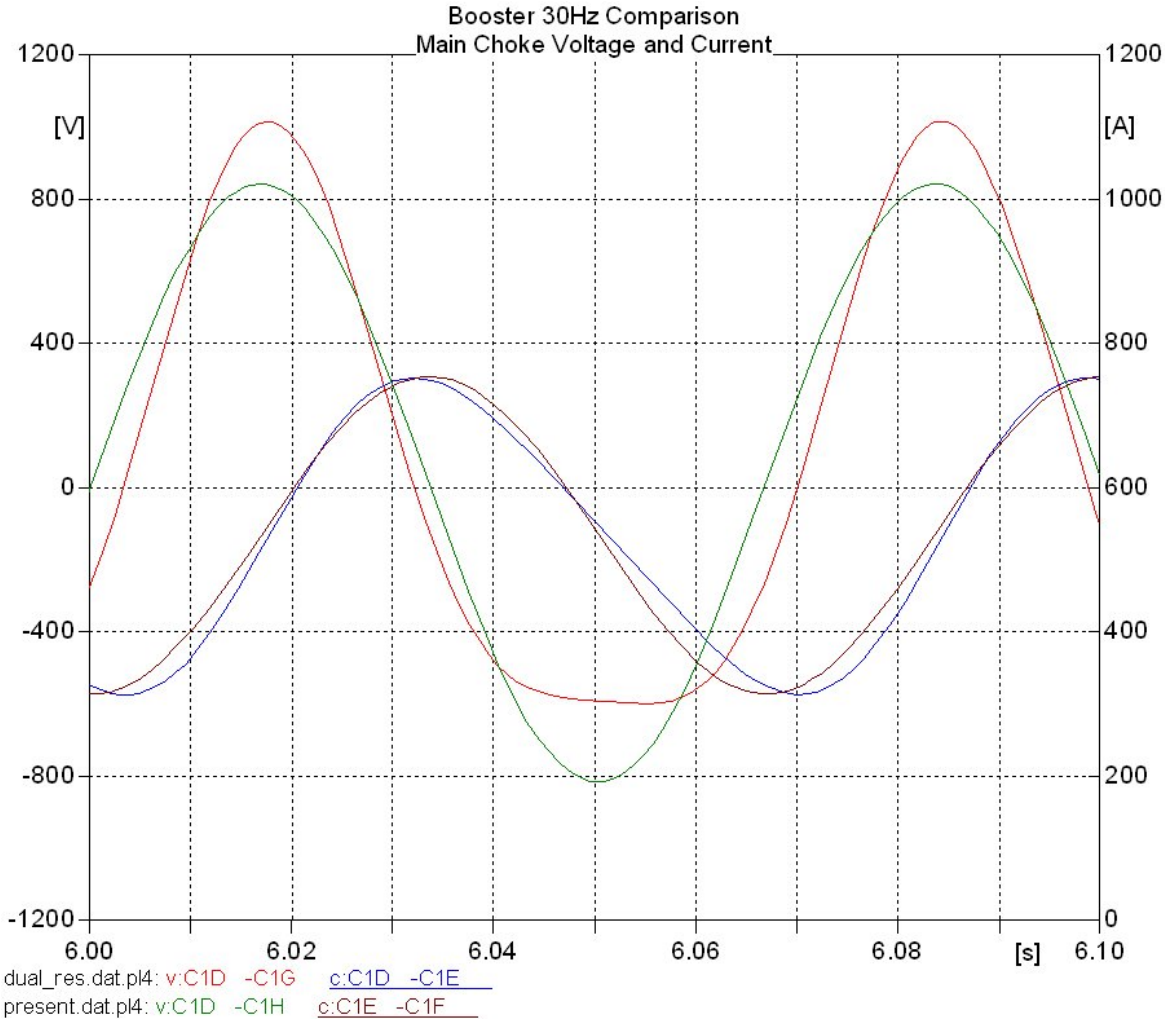
  If yes, a phased approach to modifying the booster would be possible.
- Build (final) new regulation hardware and test at E4R and with operational booster.
- Order capacitors and inductors
- Determine changes needed to allow Booster Power supplies to invert and estimate cost.
- Ongoing studies and simulations in Booster to understand effect on beam

Time Line

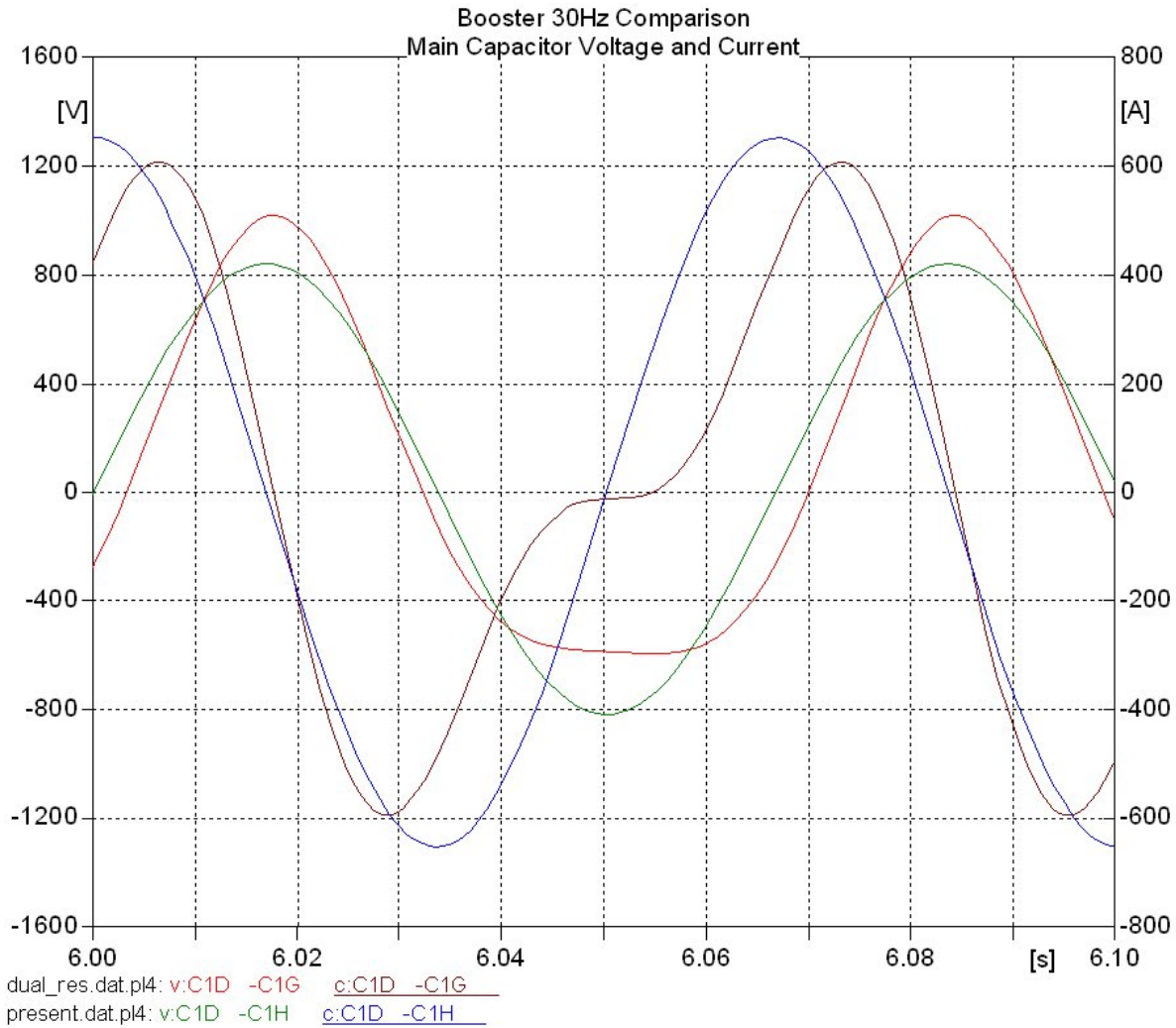

2005
2006
TASK
Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Complete testing at E4R
Modify Spare Booster girder and test
Modify 1 operational Booster girder and test
Order Inductors and Capacitors
Study AC line affects
Build Final Regulation Hardware and Test
PS Invert Design
INSTALLATION
(Install inductors, capacitors, and modify power supplies)

MISCELLANEOUS SLIDES FOLLOW

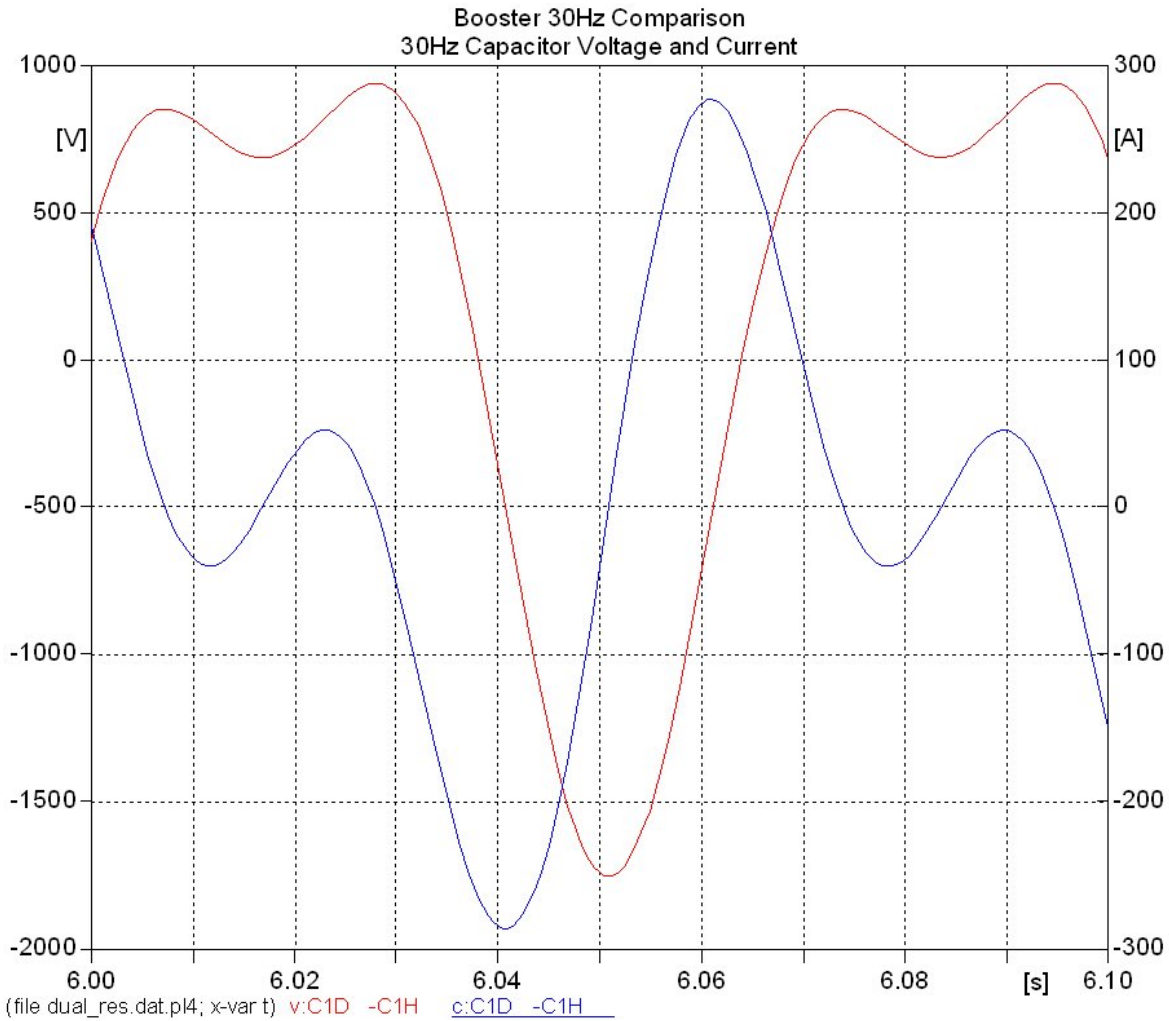
Main Choke Voltage and Current Waveforms



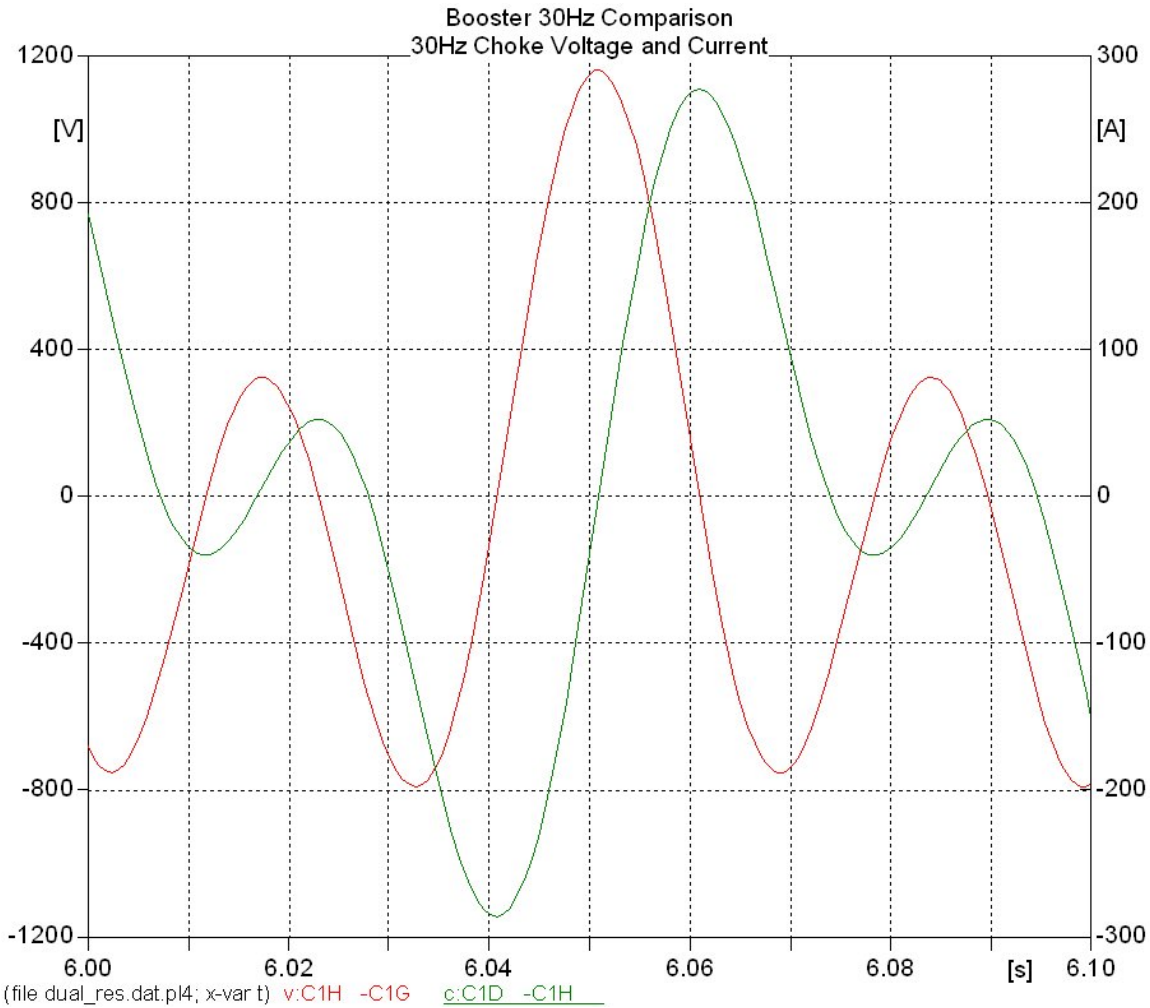
Main Cap Voltage and Current Waveforms



30 Hz Capacitor Voltage and Current Waveforms



30 Hz Choke Voltage and Current Waveforms



E4R Proto-type Current Regulator